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(54) Title: MULTI-LAYERED HIGH-DENSITY RECORDING MEDIUM AND OPTICAL POWER ADJUSTING METHOD THEREFOR

| PIC Data Zone | Disc Information ID |
|---------------------|---|
| | disc structure (0000:0010 = DL) |
| | Maximum dc read power for Layer 1 |
| | Maximum dc read power for Layer 2 |
| | Maximum HF modulated read power for Layer 1 |
| | Maximum HF modulated read power for Layer 2 |
| | Write power setting at Nominal Recording Velocity for Layer 1 |
| | Write power setting at Nominal Recording Velocity for Layer 2 |
| | Write power setting at Maximum Recording Velocity for Layer 1 |
| | Write power setting at Maximum Recording Velocity for Layer 2 |
| | Write power setting at Minimum Recording Velocity for Layer 1 |
| | Write power setting at Minimum Recording Velocity for Layer 2 |
| | |
| | |
| | |
| | |

(57) Abstract: The present invention relates to a multi-layered high-density recording medium and an optical power adjusting method therefor. A multi-layered high-density recording medium of the present invention includes optical power related information for all layers, and a optical power adjusting method of the present invention reads first optical power related information for all layers from a multi-layered optical disk placed in a disk player, stores the read information in another storage device, and immediately makes a current optical power optimal to a moved layer without accessing the placed multi-layered optical disk by referring to the stored optical power related information when moving to another layer during record or reproduction.

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DESCRIPTION

MULTI-LAYERED HIGH-DENSITY RECORDING MEDIUM AND OPTICAL POWER ADJUSTING METHOD THEREFOR

1. Technical Field

5 The present invention relates to a multi-layered high-density recording medium and an optical power adjusting method therefor.

2. Background Art

10 Recently, the standardization for Blu-ray Rewritable (referred to as BD-RE hereinafter), which is a new high-density rewritable optical disk, capable of recording high-quality video and audio data for a long time, is in rapid progress. BD-RE related products will be available on the market when the standardization is completed.

15 The data recording layer of a single-layered BD-RE disk is located at a distance of 0.1 mm from the disk surface in the direction normal to an objective lens 11 contained in an optical pickup, as illustrated in FIG. 1.

20 For recording/reproducing data on/from the recording layer of the BD-RE, the laser power of a laser diode (LD) 13 contained in the optical pickup is adjusted according to the operation mode, which will be described in detail below.

25 FIG. 2 shows a table of disk information recorded in the lead-in area of a conventional single-layered BD-RE. The lead-in area comprises a pre-recorded area and a rewritable area and the pre-recorded area includes a PIC (Permanent Information & Control) data zone.

30 As illustrated in FIG. 2, information such as the disk information ID, the disk structure, and a maximum DC read power and a maximum high-frequency modulated read power for

adjusting read power is recorded in the PIC data zone.

Also, write power settings at a normal recording velocity, write power settings at a maximum recording velocity, and write power settings at a minimum recording velocity for adjusting write power are recorded in the PIC data zone.

An optical disk apparatus in which the BD-RE having the information shown in FIG. 2 is placed adjusts the amount of the current that flows through the LD contained in the optical pickup optimal to the present operation mode by referring to the disk information stored in the PIC data zone before beginning reproducing data recorded on the recording layer of the BD-RE or recording data on the recording layer of the BD-RE.

On the other hand, dual-layered BD-RE disks having a storage capacity twice as much as that of a single-layered BD-RE disk have been proposed. A dual-layered BD-RE has two recording layers, Layer 1 and Layer 2, located at a prescribed distance (d_2) away from each other, as illustrated in FIG. 3.

The optical power of the LD 13 needs to be adjusted appropriately for recording data on a layer or reproducing data from a layer in the same way as the case for a single-layered disk. If optical power related information only for either of the layers is recorded or an identical optical power is employed for both layers, the recording/reproducing performance is likely to be deteriorated on one of the two layers. For example, suppose that an optical read power set appropriately for Layer 1 is used to read data recorded on Layer 2. A portion of the laser beam reflected by Layer 2 is reflected again by Layer 1 located below. Also, a portion of the laser beam created by the LD 13 is reflected by Layer 1 before reaching Layer 2, which results in an optical loss. For these reasons, the data recorded on Layer 2 may not be read successfully, though data reproducing on Layer 1 is successful.

As a result, it is required to maintain optical power

related information for each of the recording layers separately. Optical power related data for Layer 1 is recorded in the lead-in area of Layer 1 and optical power related data for Layer 2 is recorded in the lead-out area of Layer 2. When
5 jumping from Layer 1 to Layer 2 in the middle of a reproducing/reading operation on Layer 1, the reproducing/reading operation on Layer 2 cannot start immediately after the jump until the optical power related information recorded on the lead-out area of Layer 2 is
10 accessed.

3. Disclosure of the Invention

In an effort to solve the foregoing needs, it is the object of the present invention to provide a multi-layered high-density recording medium and an optical power adjusting
15 method therefor. In the optical power adjusting method with the high-density recording medium, optical power can be adjusted optimal to each of the recording layers immediately after a layer jump operation is performed, thereby allowing fast start of a read/write operation after the layer jump.

20 A high-density optical disk in accordance with the invention contains optical power adjustment-related information for each of a plurality of recording layers.

An optical power adjustment method in accordance with the invention comprises the steps of reading optical power
25 adjustment information for all of a plurality of recording layers from a multi-layered optical disk placed in an apparatus and storing the optical power adjustment information; searching the stored information to find the optical power adjustment information for a recording layer
30 that is the target of a requested reproducing/recording operation; and setting an optical power appropriate for the recording layer by referring to the found optical power adjustment information.

Another optical power adjustment method in accordance
35 with the invention comprises the steps of: reading optical power adjustment information for all of a plurality of

recording layers from a multi-layered optical disk placed in an apparatus and storing the optical power adjustment information in a storage means; and, in case of jumping to another recording layer during a recording or reproducing session on a recording layer, setting an optical power appropriate for the recording layer that is the target of the jump operation by referring to the optical power adjustment information stored in the storage means without accessing the optical disk and continuing the recording or reproducing operation on the target recording layer.

The high-density multi-layered optical disk and optical power adjustment method in accordance with the invention provides fast optical power adjustment capability and thereby prevents a momentary pause of recording/reproducing operation even in case of layer jumps.

4. Brief Description of the Drawings

FIG. 1 illustrates the structure of a single-layered disk and an optical pickup for accessing the disk;

FIG. 2 illustrates a table of disk information recorded in the lead-in area of a single-layered BD-RE;

FIG. 3 illustrates the structure of a dual-layered disk and an optical pickup for accessing the disk;

FIG. 4 illustrates PIC data zones assigned to lead-in and lead-out areas of a high-density dual-layered optical disk in accordance with the invention;

FIG. 5 illustrates a table of disk information stored in the PIC data zone assigned in a dual-layered optical disk in accordance with the invention;

FIG. 6 illustrates an optical disk apparatus in which the present invention may be advantageously embodied;

FIG. 7 illustrates a flow diagram of an optical power adjusting method in accordance with one embodiment of the invention;

FIG. 8 illustrates a flow diagram of an optical power adjusting method in accordance with another embodiment of the invention; and

FIGS. 9a and 9b illustrate the structure of ADIP words in which optical power adjustment-related information for a plurality of recording layers is stored.

5. Best Mode for Carrying Out the Invention

5 In order that the invention may be fully understood, preferred embodiments thereof will now be described with reference to the accompanying drawings.

FIG. 4 illustrates the structure of a dual-layered BD-RE disk in accordance with the invention, wherein a lead-in area and a lead-out area of the disk exist on Layer 1 and Layer 2 respectively and each layer has an outer zone in the outer-diameter of the disk.

The lead-in area of Layer 1 and lead-out area of Layer 2 contain separate PIC data zones that contain the same optical power related data for adjusting read/write optical power for both recording layers.

In other words, the PIC data zones recorded in the lead-in area of Layer 1 and lead-out area of Layer 2 contain the same disk information. As illustrated in FIG. 5, the disk information includes disk information ID and disk structure information. The disk structure information is an identification number indicative of a dual-layered optical disk. The identification number may indicate the number of recording layers. For example, '0000 0011' indicates a three-layer disk, '0000 0010' indicates a dual-layered disk, and '0000 0001' indicates a single-layered disk.

The disk information further includes a maximum DC read power for Layer 1 and a maximum DC read power for Layer 2, a maximum high-frequency modulated read power for Layer 1, and a maximum high-frequency modulated read power for Layer 2, all information being for adjusting read powers for Layer 1 and Layer 2.

The disk information further includes write power settings at a normal recording velocity for Layer 1, write power settings at a normal recording velocity for Layer 2, write power settings at a maximum recording velocity for Layer

1, write power settings at a maximum recording velocity for Layer 2, write power settings at a minimum recording velocity for Layer 1, and write power settings at a minimum recording velocity for Layer 2, all information being for adjusting
5 write powers for Layer 1 and Layer 2.

In case of a three-layer optical disk, the disk information includes optical power related information corresponding to each of three recording layers. Likewise, in case of an N-layer optical disk, the disk information includes
10 optical power related information corresponding to each of N recording layers.

FIG. 6 illustrates a block diagram of an optical disk apparatus such as a video disk recorder (VDR) embodying the invention. The optical disk apparatus comprises an optical
15 pickup 50 for reading recorded signals from a dual-layered BD-RE disk 200 or for recording external input data on the BD-RE disk 200, a VDR system 51 for processing the signals received from the optical pickup 50 or for converting an input data stream into a data stream formatted for recording, and an
20 encoder 52 for encoding an external analog input signal and outputting the encoded signal to the VDR system 51.

FIG. 7 illustrates a flow diagram of recording/reproducing data on/from the dual-layered BD-RE disk 200 in the optical disk apparatus shown in FIG. 6.

25 Once the dual-layered BD-RE disk 200 is inserted, the VDR system 51 starts a disk loading operation (S10).

Then the optical disk apparatus accesses the lead-in area located on Layer 1 of the dual-layered BD-RE 200 by moving the optical pickup 50 (S11) and performs a pre-read/pre-write
30 operation of reading the disk information and defect address management information (called 'DMA') recorded in the lead-in area and storing the read information in a memory (not illustrated in FIG. 6) contained in the optical disk apparatus (S12). Optical power related information is read once by the
35 pre-read/pre-write operation.

If a request to record data on BD-RE 200 or to reproduce

data from BD-RE 200 is received (S13), the VDR system 51 examines for which layer the request is issued.

If the request is associated with Layer 1 (S14), the VDR system 51 searches the disk information stored in the memory 5 for the optical power related data for Layer 1 (S15).

Then the optical disk apparatus adjusts the read/write optical power of the LD contained in the optical pickup 50 according to the read optical power related data for Layer 1 (S16).

10 After the optical power adjustment operation finishes, the optical disk apparatus begins the requested read/write operation on Layer 1 (S17).

If the received request to read data or to record data is associated with Layer 2, the VDR system 51 searches the disk 15 information stored in the memory for the optical power related data for Layer 2 included in the disk information (S18), adjusts the read/write optical power of the LD according to the read optical power related data for Layer 2 (S19), and performs the requested read/write operation (S20).

20 If a request for a layer jump, for example, a jump from Layer 1 to Layer 2, is received while a read/write operation is being performed (S21), the VDR system 51 adjusts the optical power of the LD suitably for Layer 2 by consulting the optical power adjustment-related information for Layer 2 25 stored in the memory (S22) before starting a read/write operation on Layer 2 (S23).

Consequently, in the case of jump operations, a data read/write operation can resume immediately after the jump operation without an additional latency.

30 FIG. 8 illustrates a flow diagram of an optical power adjustment method in accordance with another embodiment of the invention, wherein optical power adjustment-related information for Layer 1 is recorded only in the lead-in area of Layer 1 and optical power adjustment-related information 35 for Layer 2 is recorded only in the lead-out area of Layer 2.

Once the dual-layered BD-RE disk 200 is inserted, the VDR

system 51 starts a disk loading operation (S30).

Then the optical disk apparatus accesses the lead-in area located on Layer 1 and the lead-out area located on Layer 2 successively by moving the optical pickup 50 (S31) and reads the disk information and defect address management information to store the read information in a memory (not illustrated in FIG. 6) contained in the optical disk apparatus (S32). Disk information recorded on every recording layers is read once in this manner before the requested read/write operation.

10 If a request to record data on BD-RE 200 or to reproduce data from BD-RE 200 is received (S33), the VDR system 51 examines for which layer the request is issued.

If the request is associated with Layer 1 (S34), the VDR system 51 searches the disk information stored in the memory for the optical power related data for Layer 1 (S35).

Then the optical disk apparatus adjusts the read/write optical power of the LD contained in the optical pickup 50 according to the read optical power related data for Layer 1 (S36).

20 After the optical power adjustment operation finishes, the optical disk apparatus begins the requested read/write operation on Layer 1 (S37).

If the received request to read data or to record data is associated with Layer 2, the VDR system 51 searches the disk information stored in the memory for the optical power related data for Layer 2 included in the disk information (S38), adjusts the read/write optical power of the LD according to the read optical power related data for Layer 2 (S39), and performs the requested read/write operation (S40).

30 If a request for a layer jump, for example, a jump from Layer 1 to Layer 2, is received while a read/write operation is being performed (S41), the VDR system 51 adjusts the optical power of the LD suitably for Layer 2 by consulting the optical power adjustment-related information for Layer 2 stored in the memory (S42) before starting a read/write operation on Layer 2 (S43).

Consequently, though optical power adjustment-related information for each recording layer is stored only on the corresponding layer, a data read/write operation can resume immediately after a jump operation without an additional
5 latency.

Instead of recording the optical power adjustment-related information in the PIC data zone assigned to the lead-in and lead-out areas as described above, it is possible to record the optical power adjustment-related information in the ADIP
10 (Address In Pregroove) encoded in wobble tracks. The ADIP formation format is as follows.

56 nominal wobble lengths (NWLs) constitute an ADIP unit. An ADIP unit has 9 different types as illustrated in FIG. 9a. 83 ADIP units in turn constitute an ADIP word. FIG. 9b
15 illustrates the format of an ADIP word. As shown in FIG. 9b, an ADIP word may contain 60-bit data (nibbles c0~c14), which are recorded by encoding for error correction and hence contain 36 information bits.

24 bits of the 36 information bits are used as an ADIP
20 address and the remaining 12 bits are used as auxiliary information. Since an ADIP word can store 12-bit auxiliary information, N ADIP words are grouped to secure a space enough for storing optical power adjustment-related information and the optical power adjustment-related information for all the
25 layers is stored there. The information is stored repeatedly in groups of N ADIP words.

Although certain specific embodiments of the present invention have been disclosed, it is noted that the present invention may be embodied in other forms without departing
30 from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes that come within the meaning and range of equivalency
35 of the claims are therefore intended to be embraced therein.

CLAIMS

1. A high-density optical disk, comprising a plurality of recording layers and containing optical power adjustment-related information for each of the plurality of recording
5 layers.

2. The high-density optical disk set forth in claim 1, wherein said optical power adjustment-related information for each of the plurality of recording layers is recorded equally on each of the plurality of recording layers

10 3. The high-density optical disk set forth in claim 1, wherein said optical power adjustment-related information is recorded in disk information zone contained in the permanent information control (PIC) data zone assigned to said optical disk.

15 4. The high-density optical disk set forth in claim 3, wherein disk information stored in said disk information zone includes read optical power related data for all of the plurality of recording layers, write optical power related data for all of the plurality of recording layers, and disk
20 structure information for all of the plurality of recording layers.

5. The high-density optical disk set forth in claim 4, wherein said read optical power related data includes maximum DC read power data and maximum high-frequency modulated read
25 power data.

6. The high-density optical disk set forth in claim 4, wherein said write optical power related data includes write power data at a normal recording velocity, write power data at a maximum recording velocity, and write power data at a
30 minimum recording velocity.

7. The high-density optical disk set forth in claim 4, wherein said disk structure information is information indicative of the number of recording layers formed in said optical disk.

8. The high-density optical disk set forth in claim 1, wherein said optical power adjustment-related information for each of the plurality of recording layers is recorded in said recording layers in a distributed manner and optical power
5 adjustment-related information recorded in each of the plurality of recording layers includes information only for the corresponding recording layer.

9. The high-density optical disk set forth in claim 1, wherein said optical power adjustment-related information for
10 each of the plurality of recording layers is encoded in wobble tracks.

10. The high-density optical disk set forth in claim 1, wherein said optical power adjustment-related information for each of the plurality of recording layers is recorded in the
15 lead-in area of a recording layer and in the lead-out area of another recording layer.

11. An optical power adjustment method, comprising the steps of:

(a) reading optical power adjustment-related information
20 for all of a plurality of recording layers from a multi-layered optical disk placed in an apparatus and storing the read optical power adjustment-related information;

(b) searching the stored information to find the optical power adjustment-related information for a recording layer
25 that is the target of a requested reproducing/recording operation; and

(c) setting an optical power appropriate for the recording layer by referring to the found optical power adjustment-related information.

30 12. The optical power adjustment method set forth in claim 11, wherein said step (a) reads the optical power adjustment-related information for all of the plurality of recording layers from a specific area assigned to an arbitrary recording layer.

35 13. The optical power adjustment method set forth in claim 11, wherein said step (a) reads the optical power

adjustment-related information for all of the plurality of recording layers by searching all of the plurality of recording layers sequentially.

14. The optical power adjustment method set forth in 5 claim 11, further comprising the step of:

in case of jumping to another recording layer during a recording or reproducing session on a recording layer, searching the stored information to find the optical power adjustment-related information for the recording layer that is 10 the target of the jump operation and setting an optical power appropriate for the target recording layer by referring to the found optical power adjustment-related information.

15. An optical power adjustment method, comprising the steps of:

15 reading optical power adjustment-related information for all of a plurality of recording layers from a multi-layered optical disk placed in an apparatus and storing the optical power adjustment-related information in a storage means; and

in case of jumping to another recording layer during a 20 recording or reproducing session on a recording layer, setting an optical power appropriate for the recording layer that is the target of the jump operation by referring to the optical power adjustment-related information stored in said storage means without accessing said optical disk and continuing the 25 recording or reproducing operation on the target recording layer.

FIG. 1

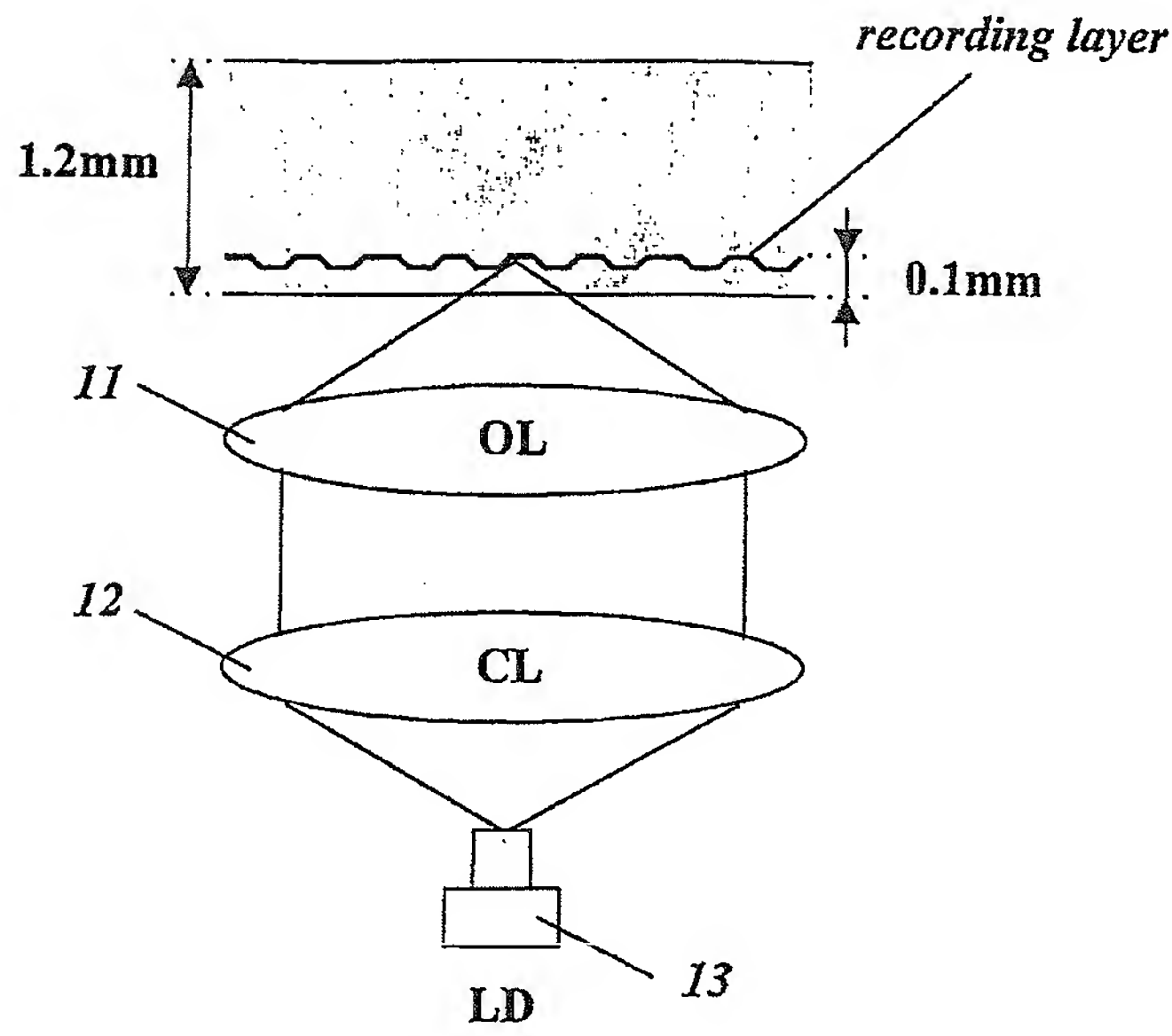


FIG. 2

| Lead-In | | Data Area | Lead-Out |
|---------------------|---|-----------|----------|
| PIC Data Zone | Disc Information ID | | |
| | ⋮ | | |
| | disc structure | | |
| | ⋮ | | |
| | Maximum dc read power | | |
| | Maximum HF modulated read power | | |
| | ⋮ | | |
| | Write power setting at Nominal Recording Velocity | | |
| | Write power setting at Maximum Recording Velocity | | |
| | Write power setting at Minimum Recording Velocity | | |
| | ⋮ | | |

Disc Information

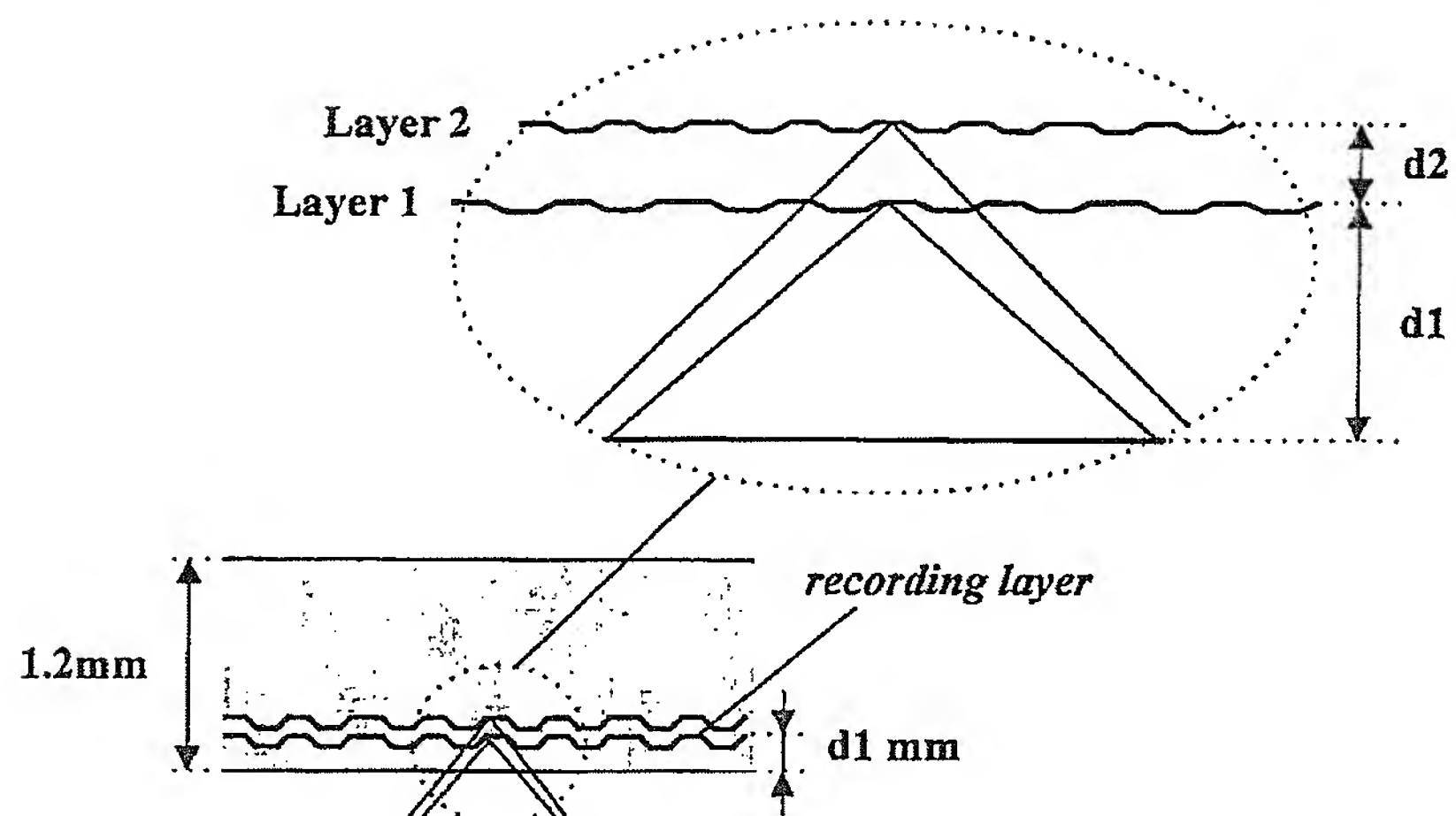


FIG. 3

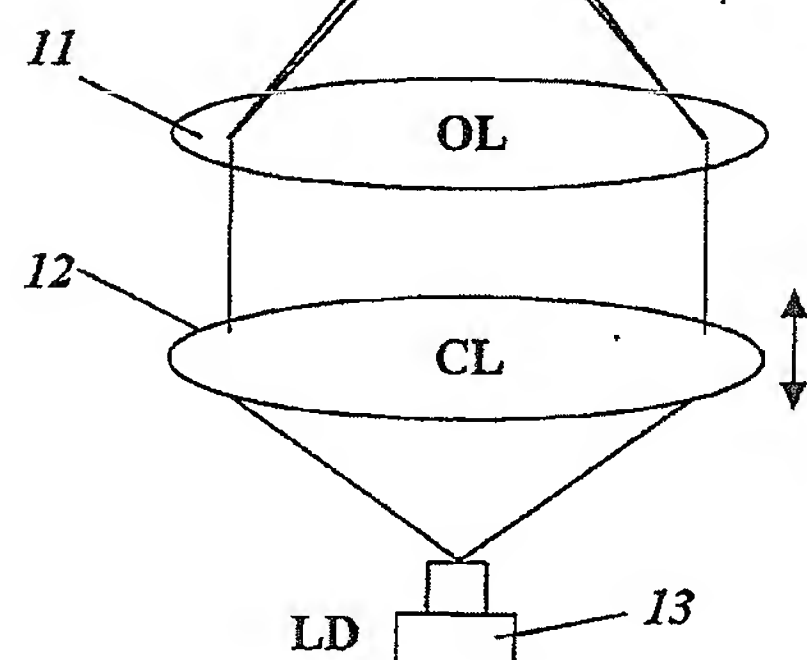


FIG. 4

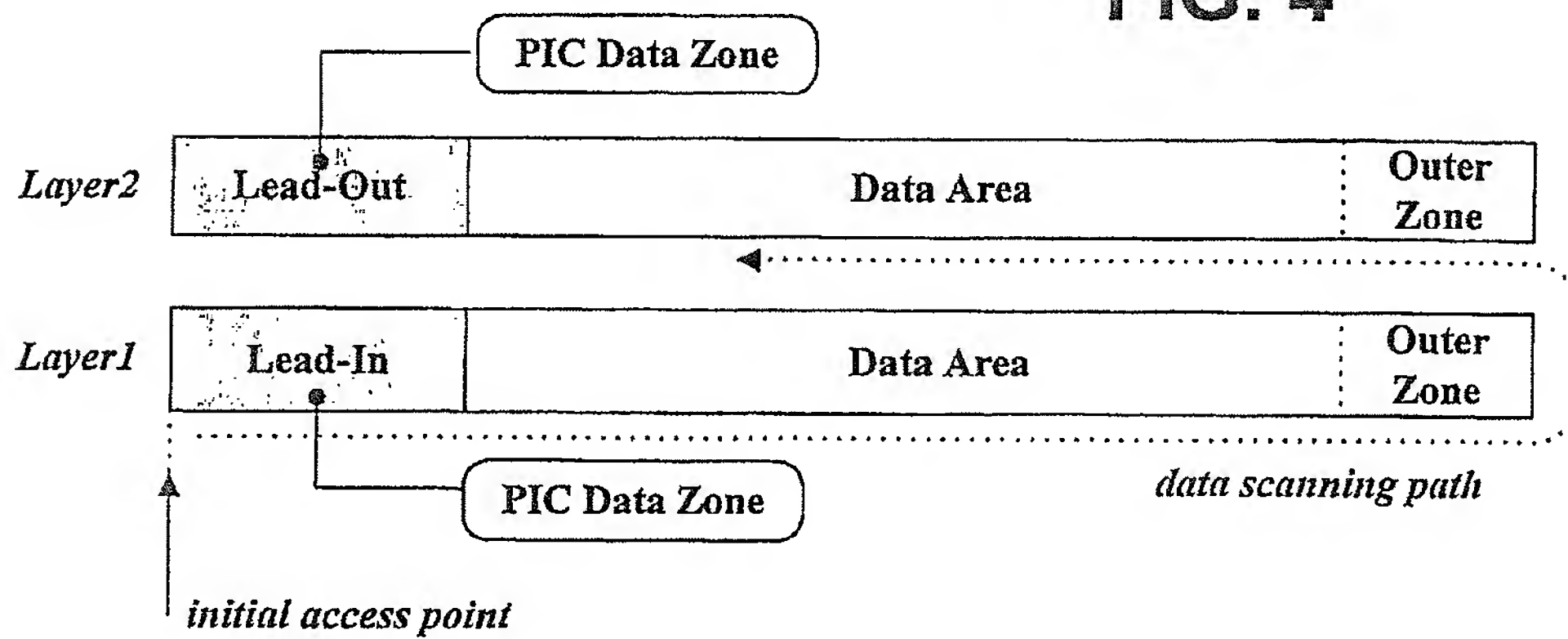


FIG. 5

| | |
|---------------------|---|
| PIC Data Zone | Disc Information ID |
| | ⋮ |
| | disc structure ('0000 0010' = DL) |
| | ⋮ |
| | Maximum dc read power for Layer 1 |
| | Maximum dc read power for Layer 2 |
| | Maximum HF modulated read power for Layer 1 |
| | Maximum HF modulated read power for Layer 2 |
| | ⋮ |
| | Write power setting at Nominal Recording Velocity for Layer 1 |
| | Write power setting at Nominal Recording Velocity for Layer 2 |
| | Write power setting at Maximum Recording Velocity for Layer 1 |
| | Write power setting at Maximum Recording Velocity for Layer 2 |
| | Write power setting at Minimum Recording Velocity for Layer 1 |
| | Write power setting at Minimum Recording Velocity for Layer 2 |
| | ⋮ |

FIG. 6

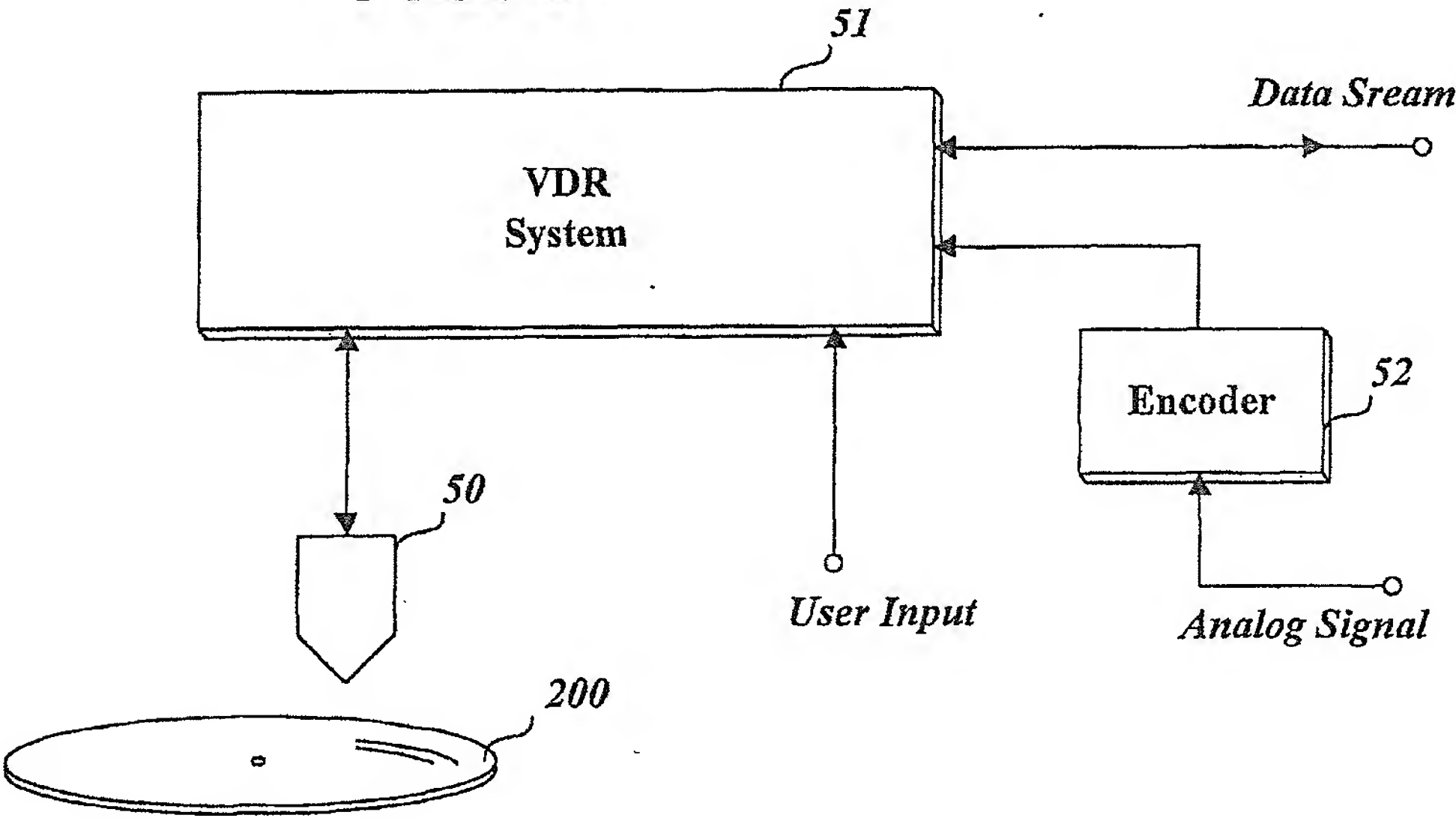


FIG. 7

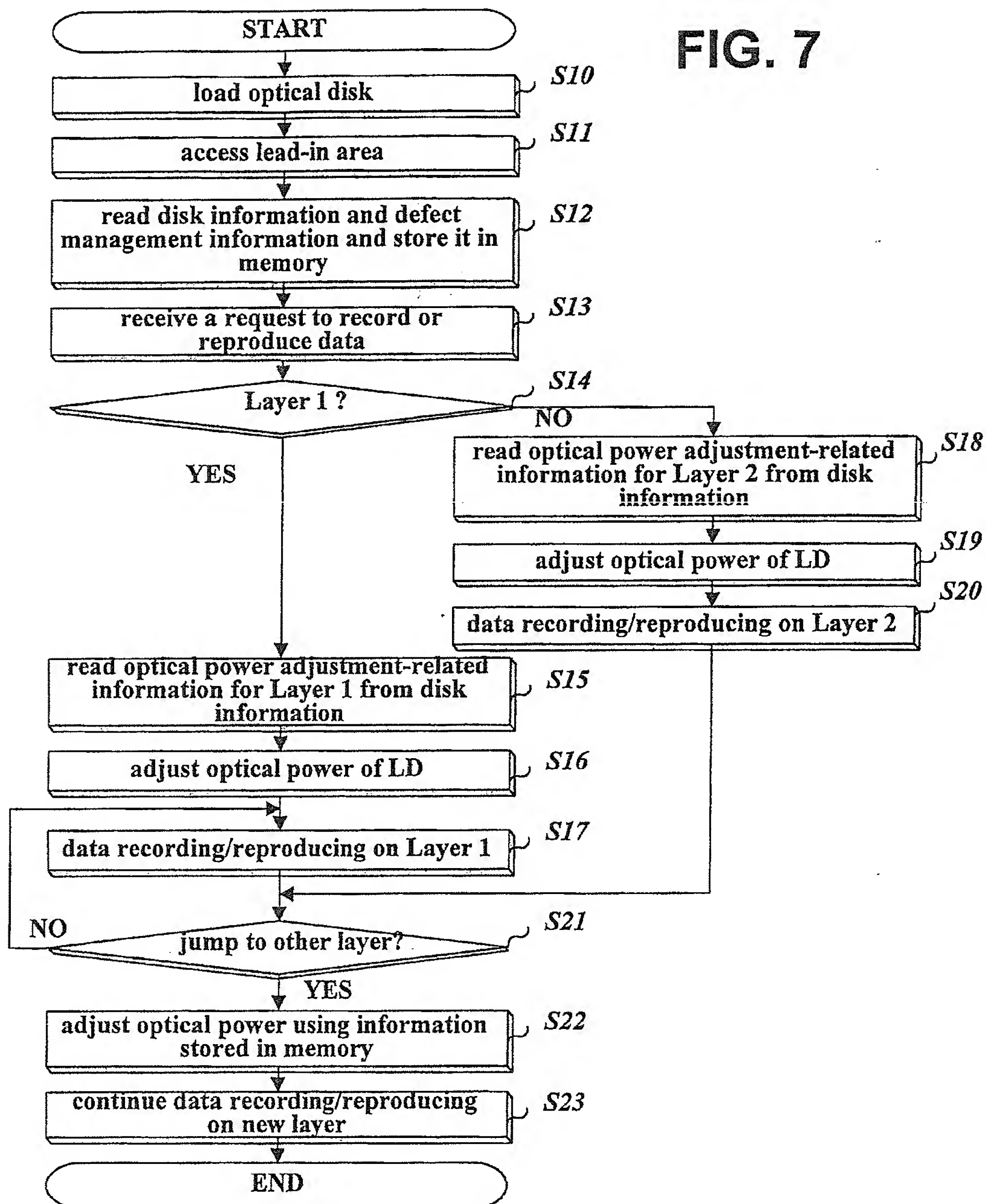


FIG. 8

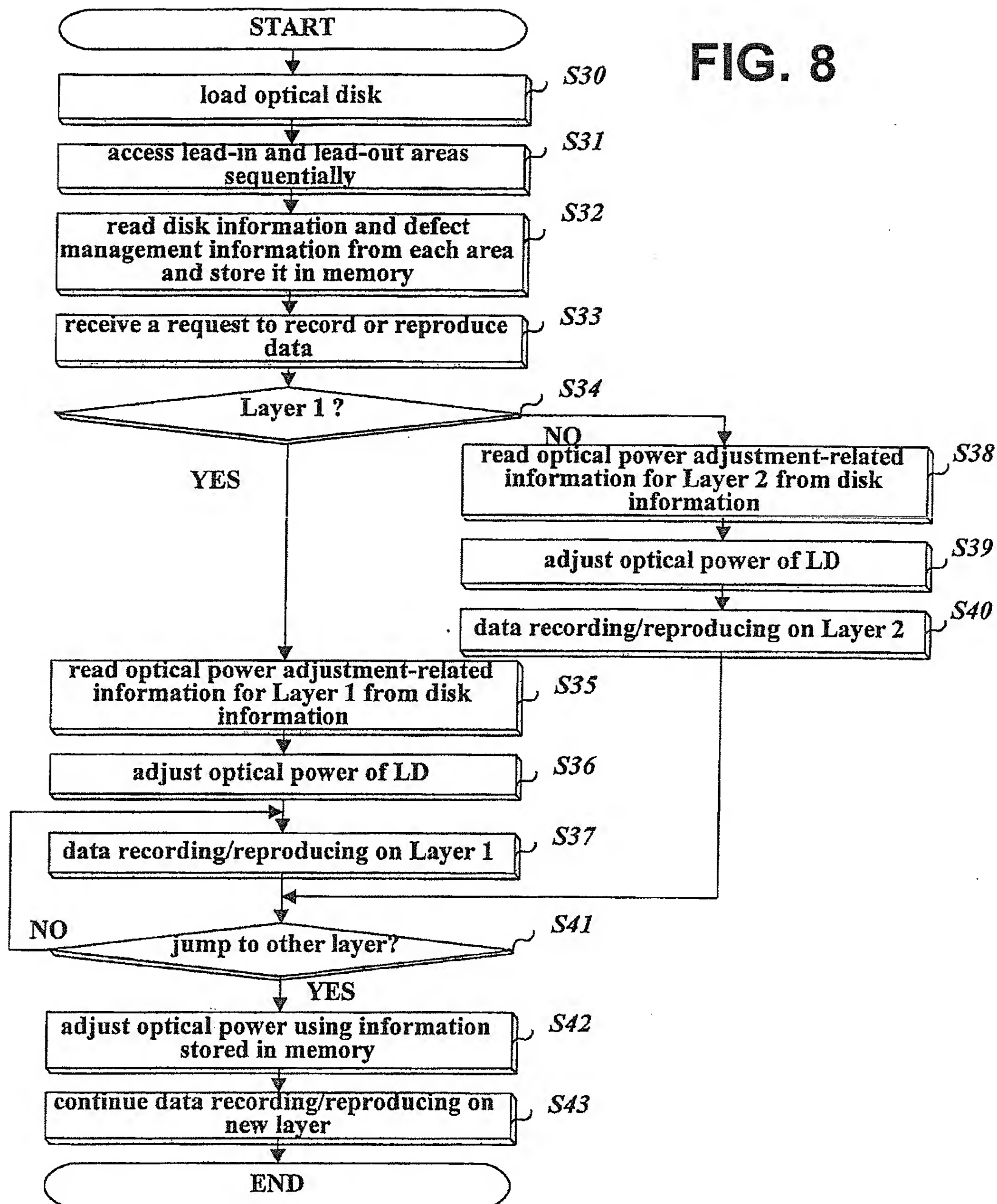


FIG. 9a

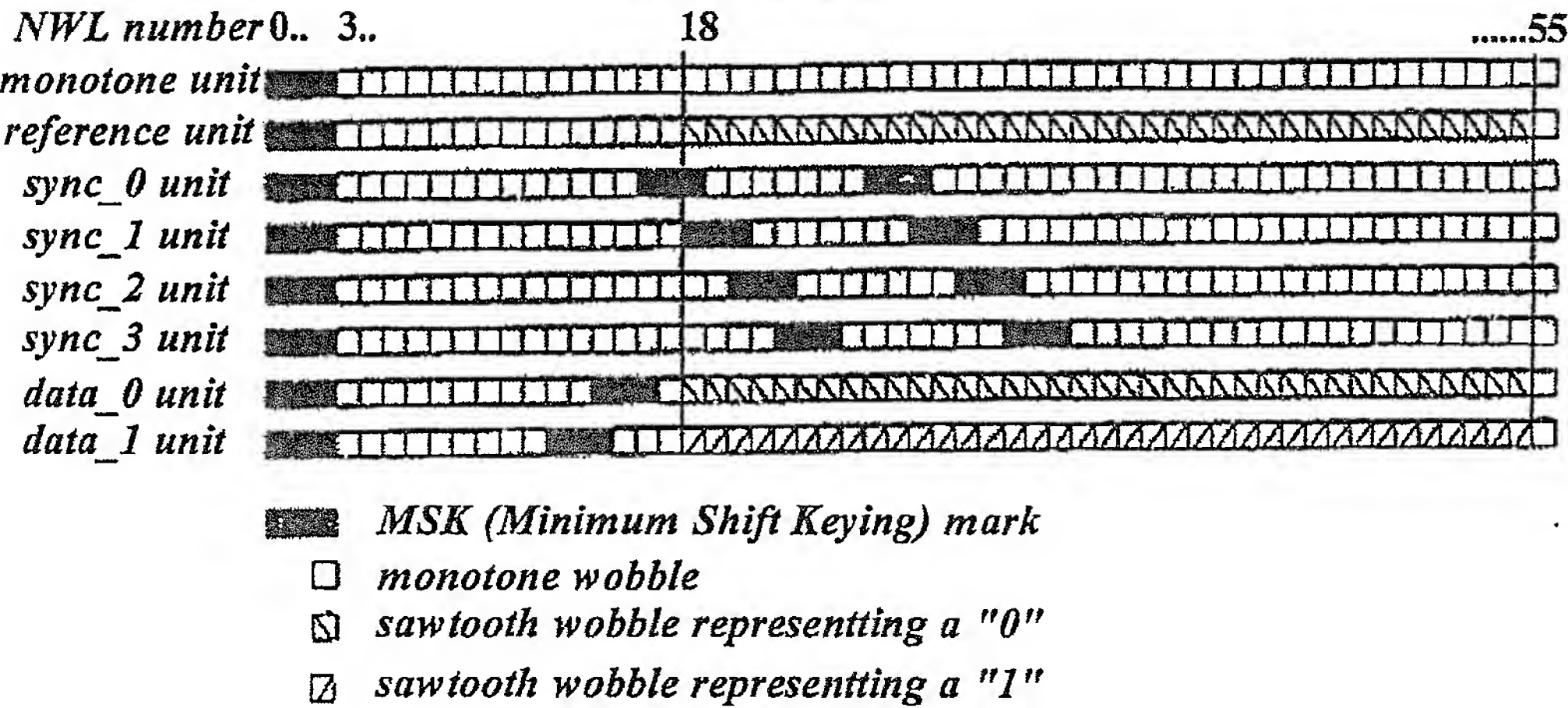


FIG. 9b

| ADIP Unit Number | ADIP Unit Type | ADIP Nibble Bit Number | ADIP Codeword Nibble Number |
|------------------|----------------|------------------------|-----------------------------|
| 0 | monotone | --- | --- |
| 1 | sync_0 | --- | |
| 2 | monotone | --- | |
| 3 | sync_1 | --- | |
| 4 | monotone | --- | |
| 5 | sync_2 | --- | |
| 6 | monotone | --- | |
| 7 | sync_3 | --- | |
| 8 | reference | --- | c0 |
| 9 | data_x | b3 | |
| 10 | data_x | b2 | |
| 11 | data_x | b1 | |
| 12 | data_x | b0 | ci |
| ⋮ | ⋮ | --- | |
| 8+i*5 | reference | --- | |
| 9+i*5 | data_x | b3 | |
| 10+i*5 | data_x | b2 | c14 |
| 11+i*5 | data_x | b1 | |
| 12+i*5 | data_x | b0 | |
| ⋮ | ⋮ | --- | |
| 78 | reference | --- | c14 |
| 79 | data_x | b3 | |
| 80 | data_x | b2 | |
| 81 | data_x | b1 | |
| 82 | data_x | b0 | |

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR03/01110

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G11B 7/007

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 G11B 7/00-7/24, G11B 20/00-20/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI, PAJ "HIGH DENSITY", "MULTI", "LAYER", "POWER", "ADJUSTMENT"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| Y | JP 10-11755 A (SONY CORP.) 16 JANUARY 1998 see abstract | 1-4, 8-10, 11-14 |
| Y | JP 05-189765 A (KYOCERA CORP.) 30 JULY 1993 see abstract | 1-4 |
| A | JP 12-311346 A (RICOH CO. LTD.) 07 NOVEMBER 2000 see the whole document | |
| A | JP 13-052337 A (RICOH CO. LTD.) 23 FEBRUARY 2001 see the whole document | |

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search

26 SEPTEMBER 2003 (26.09.2003)

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Name and mailing address of the ISA/KR



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